Zetetiké

DOI: 10.20396/zet.v28i0.8656917

Statistics performance of elementary and middle school students in the context of D-Estat

Desempenho em Estatística de estudantes do Ensino Fundamental, no contexto do D-Estat

Irene Mauricio Cazorla[1]

Miriam Cardoso Utsumi[2]

Eurivalda Santana[3]

Abstract

We analyzed the statistical performance of 1,305 students from 1st to 9th grade, in elementary and middle schools, in four public schools in the state of Bahia-Brazil, in the context of a collaborative university-school research (D-Estat). We built three instruments, according to the education level, from which we analyzed three issues involving qualitative, discrete and continuous variables; conversion of native language data to bar graphs; reading of frequency distribution and two-way tables; calculation of mean, median and mode. The main results show that performance falls substantially from one level to another, but within each school grade there is a growing trend, greater in Elementary School, signaling stagnation in the Middle School. The results indicate the need to elaborate teaching sequences validated in the reality of the schools, which allow the active role of students, in the learning processes and, consequently, for statistical literacy.

Keywords: Teaching of statistics; Elementary and middle school; diagnostic study; D-Estat.

Resumo

Analisamos o desempenho em Estatística de 1.305 estudantes do 1º ao 9º ano, do ensino fundamental, de quatro escolas públicas do interior da Bahia, no âmbito de uma pesquisa colaborativa universidade-escola (D-Estat). Construímos três instrumentos, de acordo com o nível de ensino, dos quais analisamos três questões que envolvem variáveis qualitativas, discretas e contínuas; conversão de dados em língua materna para gráficos de barras simples; leitura em tabelas simples e de dupla entrada; cálculo da média, mediana e moda. Os principais resultados mostram que o desempenho cai substancialmente de um nível para outro, mas dentro de cada nível se observa uma tendência crescente, maior nos anos iniciais, sinalizando estagnação nos anos finais. Os resultados sinalizam que é preciso elaborar sequências de ensino validadas na realidade das escolas, que possibilitem o papel ativo dos estudantes, em seus processos de aprendizagem e, consequentemente, para o letramento estatístico.

Palavras-chave: Ensino de Estatística; Ensino Fundamental; estudo diagnóstico; D-Estat.

Submetido em: 01/10/2019 – **Aceito em**: 12/02/2020 – **Publicado em**: 26/05/2020

[1] Doutora em Educação pela Universidade Estadual de Campinas. Professora da Universidade Estadual de Santa Cruz, Brasil. Email: icazorla@uol.com.br.

[2] Doutora em Educação pela Universidade Estadual de Campinas. Professora da Universidade Estadual de Campinas, Brasil. Email: mutsumi@unicamp.br.

[3] Doutora em Educação Matemática pela Pontifícia Universidade Católica de São Paulo. Professora da Universidade Estadual de Santa Cruz, Brasil. Email: eurivalda@hotmail.com.

DOI: 10.20396/zet.v28i0.8656917

Introduction

The insertion of Statistics contents in Elementary Education, in the curricular component of Mathematics in Brazil, was made official in 1997, with the publication of the National Curriculum Parameters – PCN (MEC, 1997 and 1998), forming one of the four blocks, called “Data Handling”. This trend was ratified by the National Common Curricular Base – BNCC (MEC, 2018), which included its contents in one of the five thematic units called “Probability and Statistics”.

However, based on our experience as teachers in initial and continuing education training courses; developing research on teaching and learning statistics in public schools; constructing didactic materials and supervising Master’s programs in Mathematics Education, we verified that school teachers do not sufficiently address these contents, and when they do they give more importance to the technical and operational aspects, with a fragmented, reproductive approach, disjointed from social themes and disconnected from the students’ reality, thus the “teach for teaching” the “calculation for calculation,” reproducing meaningless knowledge to the student, as pointed out by Campos, Wodewotzki and Jacobini (2013).

Therefore, with regard to this problem, we implemented the research entitled “Professional development of teachers who teach Mathematics, D-Estat” (Santana & Cazorla, 2018), carried out in the university-school partnership, intended to form a collaborative group in order to verify the viability of a model to train in-service teachers, which can independently develop and implement teaching strategies, in particular to build and validate teaching sequences, which guarantee student learning in the school environment, while respecting school culture and times.

We chose the thematic unit of Statistics because of the demand of teachers from partner schools, who recognize the importance and fragility of their knowledge and because Statistics allows, from an interdisciplinary perspective, to specifically work on Mathematics content, with transversal themes, where the student has an active role in building his/her learning process.

We started the research by conducting a diagnostic study in order to map the domain of statistical concepts that students developed over the nine grade of schooling, in order to guide the construction of the teaching sequences. This diagnostic study will also be carried out at the end of the research to verify how much this teacher training model contributed to the students' learning process.

For the selection of the statistical contents addressed, we refer to the curricular guidelines for teaching Statistics in Elementary Education and the principles that should guide this teaching, namely: statistical literacy, the investigative cycle and some assumptions of Critical Mathematics Education, which support the D-Estat, and the reading levels of graphs proposed by Curcio (1989) and of tables proposed by Wainer (1992), which help us to analyze the tasks. Below, we present some of related works, which allow us to discuss the

DOI: 10.20396/zet.v28i0.8656917

results; the methodological path, the main results of the diagnostic study and, finally, some of the considerations presented.

Curricular teaching guidelines for Statistics in Elementary Education

With regard to specific knowledge for the area of Mathematics, the PCN stipulated four content blocks: Numbers and operations, Space and Form, Greatness and Measures and Data Handling. BNCC has stipulated five thematic units: Numbers, Algebra, Geometry, Quantities and Measures, and Probability and Statistics. The statistical concepts that were presented in the Data Handling block became part of the thematic unit Probability and Statistics, as shown in Table 1.

Table 1- Statistical concepts indicated in the PCN and BNCC

PCN (MEC, 1997 and 1998)	BNCC (MEC, 2018)
● Basic concepts of Statistics: population, sample, census, sampling, variables, types of variables, data, frequency and relative frequency; ● Data collection, organization and description. ● Interpretation and preparation of lists, flowcharts, statistical tables, two-way table; ● Reading and construction of graphs, pictographs, circle, bars (simple, side by side, stacked and opposite), line graphs, histogram, and frequency polygons. Synthesize information and draw inferences; ● Measures of center (Mean, Median and Mode); ● Production of written texts, based on the interpretation of graphs and tables.	● Reading tables and bar graphs; ● Conduct research involving categorical and numerical variables; ● Data collection, organization and description; ● Interpretation and elaboration of lists, statistical tables, two-way table, flowcharts; ● Solve problems whose data is in tables or graphs; ● Reading and construction of bar graphs, grouped bar graphs, pictographs, circle graph, line graphs; ● Differentiation between categorical and numerical variables; ● Sample and census research; ● Measures of center (Mean, Median and Mode); ● Data dispersion (range).

Source: MEC (1997, 1998 and 2018).

The statistical concepts listed in Table 1 are practically the same in both documents, with the BNCC reinforcing the need for methodological work with research from the 1st to the 9th grade, with the planning and execution of sample research aimed at the social reality. In addition, it is expected that schools will make it possible to develop education competencies and ability for students.

We emphasize that the research group that develops D-Estat in schools believes that Statistics is a powerful tool that can contribute to the education of the general public, allowing them able to interpret the world. For that, some principles must be assumed for its teaching of statistical literacy, the investigative cycle, the perspective of Critical Mathematics Education, that is, to empower students with a form of Statistics that is useful for their personal life and in society.

Statistical Literacy and Critical Mathematics Education

The use of statistics concepts and procedures in the reading and modeling of the phenomena that permeate the world has been called statistical literacy which, for Gal (2002),

DOI: 10.20396/zet.v28i0.8656917

goes beyond the domain of statistical procedures, with the general public's competence to discuss or communicate their understanding regarding information, expressing opinions on such implications and form the conclusions drawn.

This author proposes a statistical literacy model formed by two components: one cognitive and the other attitudinal. The cognitive one consists of five elements: literacy skills, statistical knowledge, mathematical knowledge, context knowledge and the ability to formulate critical questions. The attitudinal one is composed of two elements: critical stance, beliefs and attitudes.

Operationalizing elements of the Gal (2002) model in the classroom requires experiencing all the logic of statistical investigations, with a critical and reflective focus. Therefore, we agree with Cazorla and Santana (2010) when they state that "in order to provide statistical literacy to the student, we also need to develop statistical thinking, so that the student will critically reflect on all phases of the research" (p. 13).

Also observed is that criticality is present in the two components of Gal's model (2002), given that the ability to elaborate critical questions concerns the population's ability to question whether that concept used is adequate or if another one could have been used, while the critical stance concerns the ability to position oneself in face of results of the investigation.

Skovsmose (2008) discusses the social role of mathematics in favor of democracy, viewing the teaching of mathematical content as a possibility for individuals to develop their critical ability within any context.

We believe that the perspective of statistical literacy, defended by Gal (2002), is in line with the perspective of Critical Mathematics Education proposed by Skovsmose (2008) that places the teaching of Mathematics beyond the teaching of contents, with a perspective of promoting in subjects a form of critical analysis of the reality in which they are inserted, contributing to the emancipation of students.

Contemporary reality is presented in different forms of representation. In the media, information is commonly displayed in tabular or graphical representation. If the intention is to contribute to broaden students' world reading, then schools fundamentally need to help them advance in their reading levels and data interpretation presented in different representations.

To analyze the level of reading of information contained in graphs, we turn to Curcio (1989) who stipulated three different understanding levels of reading graphs: "Reading the data," referring to a literal reading of the elements in graphs, without requiring the reader knows how to interpret the data beyond what is actually presented and perceptible in the representation, with a very low cognitive cost, such as finding the minimum or maximum value; "Reading between data" includes the interpretation and integration of data in the graph and requires the ability to compare quantities and the use of other mathematical concepts. This type of reading requires a certain degree of logical or pragmatic inference such as, for

DOI: 10.20396/zet.v28i0.8656917

example, identifying in which period there was greater growth or the variable that experienced the greatest variation; and “Reading beyond the data”, which is a more complex level and asks the reader for a global interpretation, not only of the data contained in the graph, but also understanding the phenomenon or the problem which emerges from the data.

Similarly, Wainer (1992) proposed three levels of understanding for reading and interpreting tables: “Elementary level”, when the reader extracts specific data from the tables, which do not require any action for their comparison and/or analysis; “Intermediate level”, when the reader interpolates and identifies what are the relationships between the data that are shown in the tables; and, “Advanced level”, when it involves a broader understanding of the structure of the data presented in its entirety, generally comparing trends and analyzing implicit relationships in the tables.

Research on student performance in Statistics

Cobo and Batanero (2004) evaluated the understanding of arithmetic mean and its properties in 53 high school students, who solved four open problems and concluded that although the idea of the mean is apparently simple, the research results indicated that for students to be successful, they must mobilize various numerical ideas in problem solving, such as the distributive property of addition and multiplication, or the inversion of the mean algorithm. In addition, they must discriminate properties that although valid for addition and multiplication, cannot be generalized to find the overall mean.

Mayén, Cobo, Batanero and Balderas (2007) studied the understanding of mean, median and mode in 125 Mexican students, aged 17 and 18, and compared the results with those of Spanish students who were 15 and 16 years old and who were in the last grade of Secondary Education. Among the results, we highlight that the researchers found that when calculating the median, students forget to order the data and that they cannot find the median with an even number of data, because “they do not know how to solve the indeterminacy produced by having two central values” (p. 196).

Luna and Carvalho (2019) analyzed the performance of 100 students (from the 6th and 9th grades of elementary and middle schools and the 3rd grade of high school from a private school in Pernambuco) on five questions about arithmetic mean, involving different meanings of this concept in situations with and without graphical representations. The results obtained showed that the level of education was a determining factor in performance, and was considered below expectations, highlighting the participants’ difficulty in division. It was observed that graphical representation negatively influenced the students' performance and that they mistakenly conceive the arithmetic mean as being: the sum of a set of values, a number that is divided by two, the central term of a set of values arranged in increasing order (median), or a number ending in zero.

Studies show that mistakes are not limited to students. Santos and Branches (2019), for example, investigated errors in statistical graphs published in the media and found several problems, such as: the absence of the ordinate axis, scale or grid lines, graph bars with disproportionate widths and heights, incompatibility of data labels with the measurements

DOI: 10.20396/zet.v28i0.8656917

presented, omission of zero and scale interruption at the beginning of the vertical axis in line graphs, among other problems.

Teixeira (2016) carried out a bibliographic research on teaching and learning content of Statistics and Probability in Basic Education. The researcher states that these contents contain elements that are very attractive to students, not only because they are present in their daily lives, but also because of the potential for developing interdisciplinary activities with the understanding and appropriation of concepts specific to society, such as insertion and social participation and politics.

Using the investigative cycle, other studies also link investigations to statistical literacy. Santana (2016) investigated the perceptions of a 3rd grade high school class at a state school in Minas Gerais that emerged after conducting investigative activities in groups of three or four students in which they chose the topic to be investigated: violence, internet, drugs, consumerism, accessibility, bullying and corruption. Such themes were developed using the phases of the investigative cycle, which according to the researcher, favored the development of characteristics of statistical literacy and student motivation, as they made the activities more pleasurable.

Nascimento, Paula and Catarino (2018), used the investigative cycle with 5th grade students in a public school in Portugal and discussed the results of a student. The approximation between reality and content allowed the learning of frequencies (absolute, relative and percentages), in addition to the registry of counts, construction of a statistical table and bar graph. The researchers concluded that the investigative activity in the context of the student's daily life enabled the use of different registries, processing and conversions, which contributed to the movement of meanings and senses.

Also with a focus on the interest of students, Carvalho, Oliveira and Monteiro (2019) proposed teacher training to 11 indigenous teachers of the early grade of elementary schooling. The teachers planned an investigation on the water resources in the villages, discussing the theme and conducting data collection through interviews with the community. The results showed that students experienced significant and critical learning, had a reasonable numerical sense to express the research results, as they estimated quantities and represented them by using circle and bar graphs. However, the researchers considered that specific conceptual aspects in the construction of graphs were still necessary to improve students' statistical literacy, in particular those related to the organization and systematization of statistical information and the use of scale in the bar graph.

It is observed in this survey, that regardless of the level of education or cultural characteristics of students, teaching practices that privilege the use of the themes chosen, or that are of their interests, addressed within the perspective of the investigative cycle, enhance the development of statistical knowledge and critical stance that can contribute to promoting social equality. These considerations will be present in the teaching sequences that will be planned and developed together with the teachers in the D-Estat project.

DOI: 10.20396/zet.v28i0.8656917

Methodological path

The research involved four schools, 65 classes and 1,305 students distributed over the nine elementary and middle school, in the interior of Bahia, distributed by school grade according to Table 2.

The instruments were designed to accompany the mastery of concepts over the nine grade and took into account the nuances of school grade, therefore we developed three instruments: one for the 1st level (1st to 3rd grades), another for the 2nd level (4th and 5th grades) and another for the Middle School (6th to 9th grades).

In this work we analyze three questions, common to the instruments of these three levels.

Table 2 - Number of subjects involved in the research, by school grade

Fundamental Education	Education levels	School grade	Expected age	No. of schools	No. of classes	No. of students
Elementary School	1st	1st	6	1	4	47
		2nd	7	1	4	60
		3rd	8	1	6	102
	2nd	4th	9	1	3	59
		5th	10	1	5	104
Middle School	3rd	6th	11	3	15	314
		7th	12	3	12	248
		8th	13	3	10	222
		9th	14	3	6	149
		Total		4	65	1.305

(*) Although this nomenclature is not officially used, we use it to facilitate understanding the work.

Source: D-Estat data.

The 1st level instrument comprised three questions, two with discrete variables and one with nominal qualitative (Table 3). The order of magnitude of the numbers was up to 25 and involved addition and division operations, in an intuitive concept of dividing. The data were presented in the native language, requesting the conversion to the graphic register and a statistical table, requesting the determination of the sum, the maximum, the minimum, the mode, the mean. From the qualitative variable, the mode and sample size were requested.

Table 3 - Structure of the instrument for the 1st level (1st to 3rd grade)

Question	Variable	Nature of the variable	Order of magnitude / operations	Representation		
				Initial	Graph	Statistics (summary measures)
Q1	Number of marbles	Discreet (genuine)	Up to 15, addition, division	Native language	Bar graph	Maximum, sum, mode, mean
Q2	Number of chocolate snacks	Discreet (genuine)	Up to 15, addition, division	Table		Maximum, sum, mode, mean

DOI: 10.20396/zet.v28i0.8656917

Q3	Favorite Pet	Nominal qualitative	Up to 25, addition	Frequency distribution table		Sample size (sum), mode

Source: D-Estat data.

The three questions of the 2nd level instrument (4th and 5th grades) had the same wording as the 1st level instrument, however the complexity was due to the order of magnitude of the numbers that reached 50, and because instead of asking for the extraction of the minimum and maximum, we requested the median. In addition, in Question 2 the data went from a table to two-way table, requesting the sum by lines, as shown in Table 4.

Table 4 - Structure of the instrument for the 2nd level (4th and 5th grade)

Question	Variable	Nature of the variable	Order of magnitude / operations	Representation		
				Initial	Graph	Statistics (summary measures)
Q1	Number of marbles	Discrete (genuine)	Up to 42, addition and division	Native language	Bar Graph	Sum, mode, mean, median
Q2	Number of chocolate snacks per day	Discrete (genuine) and qualitative	Up to 30, addition and division	Two-way table		Sum, mode, mean, median
Q3	Favorite pet	Nominal qualitative	Up to 50, addition	Frequency distribution table		Sample size, mode

Source: D-Estat data.

The three questions of the instrument for the Middle School (6th to 9th grades) maintained the same structure as the instruments of the Elementary School (1st to 5th), with some changes (Table 5). In Question 1, we just changed the name of the variable. In Question 2, in addition to the data displayed in a two-way table, we requested the sum and mean of the rows and columns, a property of the mean and comparison. In Question 3 we went from statistical table to Two-way table, requesting the relative frequency and the perception of relationships between variables.

Table 5 – Instrument structure for the Middle School (6th to 9th grade students)

Question	Variable	Nature of the variable	Order of magnitude / operations	Representation		
				Initial	Graph	Statistics (summary measures)
Q1	Amount spent at the bakery	Continuous (discretized)	Up to 50, addition, division, sort	List	Bar Graph	Sum, mode, mean, median
Q2	Student scores in two tests	Continuous (discretized) x qualitative	Up to 50, addition, division	Two-way table		Sum, mean, mean property, comparison
Q3	Favorite pet by gender	Two nominals	Up to 200, addition, division	Two-way table		Sample size, mode, relative frequency

Source: D-Estat data.

DOI: 10.20396/zet.v28i0.8656917

As we can see, the last instrument is more complex than the previous ones, since we requested reading beyond the data. However, it only contemplates the skills recommended by the BNCC and, therefore, it is expected that such content will be in the students' domain. An important question was whether students knew the names of measures of center so it was asked explicitly.

All ethical procedures for research with human beings were followed, such as filling out the Free and Informed Consent Form (FICF), authorization from the school management, and others.

The instrument was answered between May and June 2018. The students were at the beginning of the school year (strike and delay of the school year) and answered the instrument individually, during class time, under the supervision of the class teacher, who was asked not to interfere with the students' responses.

The answers were categorized as correct and not correct (wrong and blank entries) and we created the variable "percentage of correct answers," and the data were transcribed to an electronic spreadsheet.

Results and discussion

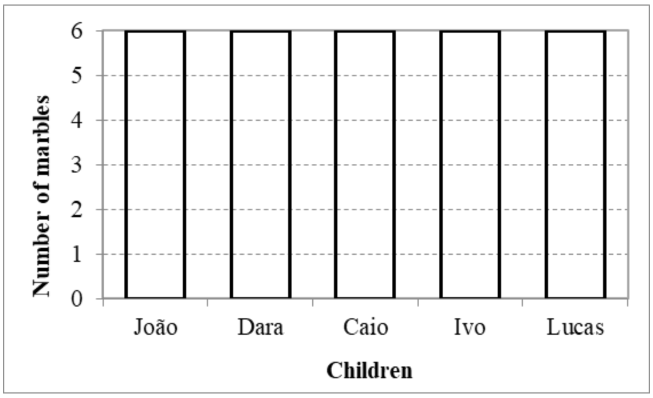
In this section we present the results in three subsections according to the levels, and in the fourth section we draw a parallel of these three levels.

Performance of 1st level students (1st grade to 3rd grade)

Question 1 (Figure 1), presented a discrete variable, with five native language data and requested six tasks: conversion of the data to a bar graph, providing the Graph's framework (G. Bars); identify the child who had the maximum (Maximum) value; the maximum value (MaxValue); the total of marbles (Sum); identify the Mode (Mode) and calculate the mean (Mean), and the Mode and Mean were requested without mentioning this nomenclature.

Q1. Five children are playing marbles in the schoolyard. João has 5, Dara has 1, Caio has 2, Ivo has 6 and Lucas has 1.

Q1a. Paint on the Graph the amount of marbles that each child has:



Q1b. Which child has the most marbles?

Q1b1. How many?

Q1c. In all, how many marbles do the five children have?

Q1d. Among the number of marbles for each child, what is the amount that is repeated most often?

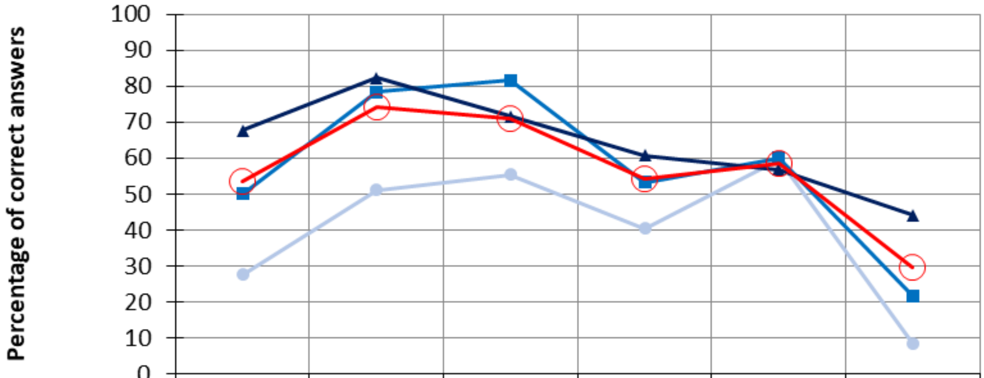
Q1e. To start the game Dara had the idea of putting all the marbles together and sharing the marbles equally among all the children. How many marbles did each child have?

DOI: 10.20396/zet.v28i0.8656917

Figure 1 – Statement of Question 1 of the 1st level.

Source: D-Estat data.

In Figure 2, we can see that performance increases with schooling in all concepts, with the exception of mode and in determining the maximum. In general, 1st grade students perform poorly. In tasks that requested reading the data, without making calculations (Maximum and Mode), the performance was above 50%, and the worst performance was in the calculation of the mean, especially in the 1st grade.



	G.bars	Maximun	Max.Value	Sum	Mode	Mean
1st. grade	27,7	51,1	55,3	40,4	59,6	8,5
2nd. grade	50,0	78,3	81,7	53,3	60,0	21,7
3rd. grade	67,6	82,4	71,6	60,8	56,9	44,1
General	53,6	74,2	70,8	54,1	58,4	29,7

Figure 2 – Percentage of correct answers of 1st level students in Question 1, per school grade.

Source: D-Estat data.

Question 2 (Figure 3) presented a discrete variable, with four data points arranged in a statistical table and requested for six tasks: the total (SumC); identify the child who ate the least (Minimum); the minimum value (MinValue); identify the implicit Mode (Mode); identify the value of Mode (ModeValue) and divide it into equal parts (Mean).

Q2. Grandma Maria prepared chocolate snacks for her grandchildren, there were none left! She counted how many chocolate snacks each grandson ate and recorded it in the Figure 1:

Figure 1 – Number of chocolate snacks each grandson ate

Grandchildren	Number of chocolate snacks
Clara	3
Luiz	4
Bia	1
Nina	4
Total Chocolate snacks	

Q2a. How many chocolate snacks did Grandma prepare in all?

Q2b. Who ate the least amount of chocolate snacks?

Q2c. How many chocolate snacks did they eat?

Q2d. Were there grandchildren who ate the same amount of chocolate snacks?

Q2e. If so, how many chocolate snacks did they eat each?

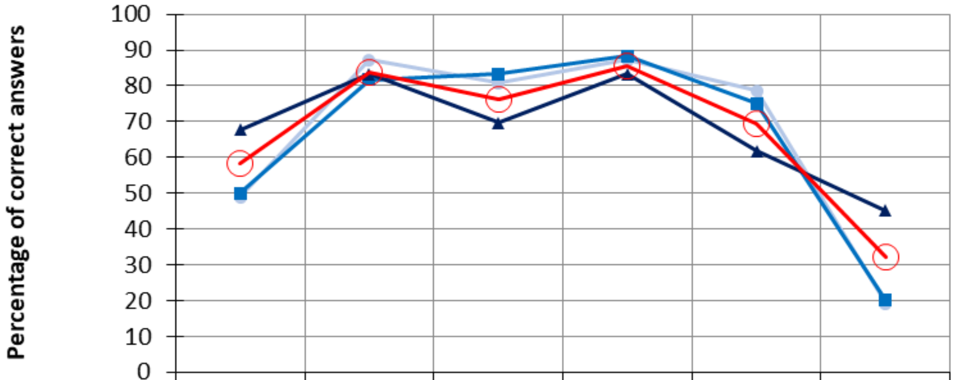
Q2f. If Grandma had said that all grandchildren should eat the same amount of chocolate snacks, how many should each child eat?

Figure 3 – Statement of Question 2 of the 1st level.

DOI: 10.20396/zet.v28i0.8656917

Source: D-Estat data.

In Figure 4, we observe that the 3rd grade students present good performance, including those of the 1st grade, signaling that the students have the elementary level of reading tables (Wainer, 1992) and with the fact that the data are in their native language or that the statistical table did not interfere with performance.



	SumC	Minimum	Min.Value	Mode	Mode.Value	Mean
1st. grade	48,9	87,2	80,9	87,2	78,7	19,1
2nd. grade	50,0	81,7	83,3	88,3	75,0	20,0
3rd. grade	67,6	83,3	69,6	83,3	61,8	45,1
General	58,4	83,7	76,1	85,6	69,4	32,1

Figure 4 – Percentage of correct answers of 1st level students in Question 2, per school grade.

Source: D-Estat data.

Question 3 (Figure 5) presented a qualitative variable in a frequency distribution table and requested two tasks: “How many students answered the question?” (Sum) and, "What is the favorite pet that most students chose?" (Mode). The results presented in Figure 6 confirm that the participants have an elementary level of table-reading ability, because to identify the favorite pet they needed to look for the maximum value (modal frequency) and associate the category (dog). Most students were unable to even perform the addition to find how many students answered the question.

DOI: 10.20396/zet.v28i0.8656917

Q3. The school teacher asked the students what their favorite pet was and she organized the data in the Figure 2:

Figure 2 – Number of students according to favorite pet

Favorite pet	Number of students
Cat	7
Bird	2
Dog	8
Turtle	3
Others (monkey, tamarin monkey, etc.)	3
None	2
Total students	

Figure 5 – Statement of Question 3 of the 1st level.

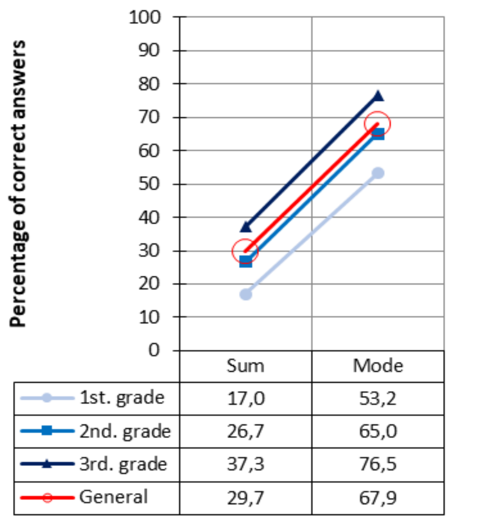


Figure 6 – Percentage of correct answers of 1st level students in Question 3, per school grade.

Source: D-Estat data.

Concluding the analysis of student performance in the 1st level, we present Figure 7. It is observed that the percentage of blank answers in each item is less than 10% and the concept of dividing in equal parts was the one that presented more blank answers (Q1f - Mean) and (Q2f-Mean). This result seems reasonable considering that in the 1st level the concept of division is one of the last to be taught and its consolidation takes longer than addition, subtraction and multiplication.

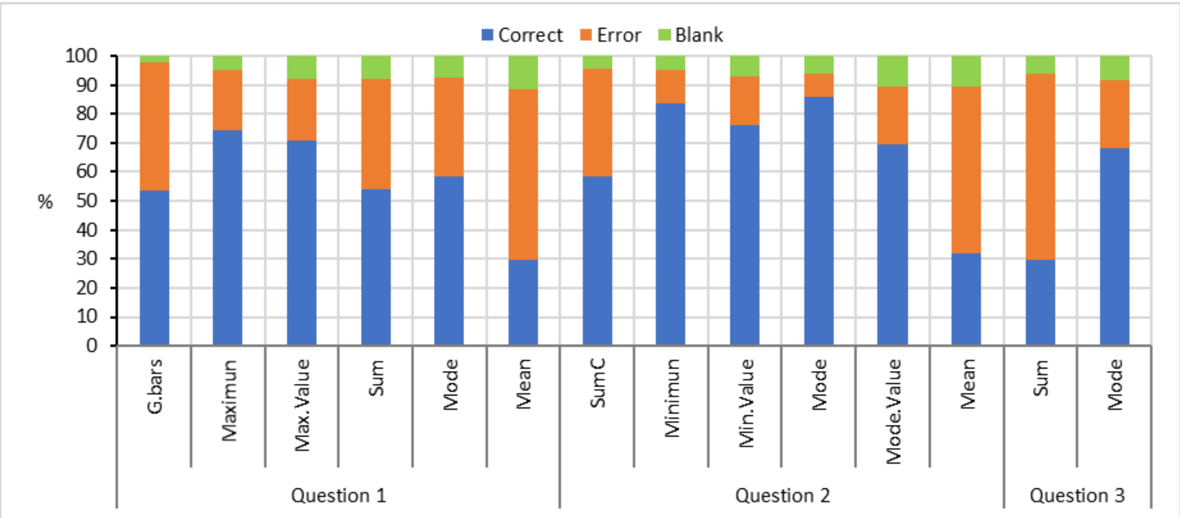


Figure 7 - Percentage distribution of correctness, error and blank, by item, of 1st level students.

Source: D-Estat data.

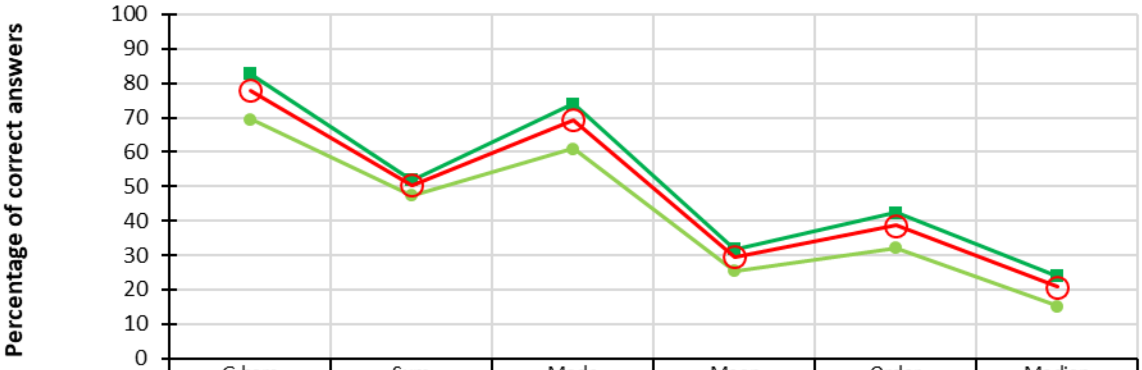
Second level of students' performance (4th and 5th grade students)

Question 1 had the same wording as the 1st level instrument, increasing the amount of data from 5 to 7 and the values: “Seven children are playing marbles in the schoolyard. João

DOI: 10.20396/zet.v28i0.8656917

has 4, Dara has 6, Caio has 4, Ivo has 10, Lucas has 9, Ana has 4 and Enzo has 5." The items requested: to convert the native language data to a bar graph (G. Bars); find the total of marbles (Sum); identify the value that is repeated most often (Mode); divide into equal parts (Mean), order (Order) and find the value that occupies the central position (Median).

In Figure 8 we can see that, in general, students did better in converting their native language data to the graphic register and find the mode; however, only half managed to add the quantities and less than a third managed to find the mean. We expected the ordering task to be relatively simple, however less than 42.3% managed to do it; similarly, we expected that finding the Median was an intuitive and easy task, since finding the central position was immediate, since the number of data was seven (odd), just reading the value of the data that occupied the 4th position; however, less than a quarter of the students were able to accomplish this task. As in the 1st level, we observed that 4th and 5th grade students have difficulties in all items that require performing any calculation.



	G.bars	Sum	Mode	Mean	Order	Median
5th. grade	69,5	47,5	61,0	25,4	32,2	15,3
4th. grade	82,7	51,9	74,0	31,7	42,3	24,0
General	77,9	50,3	69,3	29,4	38,7	20,9

Figure 8 – Percentage of correct answers for 2nd level students in Question 1, per school grade.

Source: D-Estat data.

Question 2 (Figure 9) was similar to that of the 1st level, however the data were in a two-way table requesting eight tasks: add the values of the lines (Sum L); add the column values (SumC); order the total number of chocolate snacks (Order); find the value that occupies the central position (Median), and three means (Mean1, Mean2, Mean3).

Q2. Grandma Maria prepared chocolate snacks for her grandchildren over the weekend and there were none left! She counted how many chocolate snacks each grandson ate each day and registered in Figure 1:

Figure 1 – Number of chocolate snacks that each grandson ate over the weekend.

Grandchildren	Number of chocolate snacks each child ate		
	Saturday	Sunday	on the weekend

Q2a. Fill the Figure with the total of chocolate snacks that each grandson ate over the weekend.

Q2b. Fill the Figure with the total of chocolate snacks consumed on Saturday, Sunday and the weekend.

Q2c. Place in ascending order the number of chocolate snacks consumed by the grandchildren over the weekend:

1st position	2nd position	3rd position	4th position

DOI: 10.20396/zet.v28i0.8656917

Clara	4	5	
Luiz	5	6	
Bia	3	5	
Nina	0	0	
Total cho-colate snacks			

Q2d. What is the amount of chocolate snacks that occupies the central position?

Q2e. If Grandma had said that all grandchildren should eat the same amount of chocolate snacks, how many chocolate snacks should each eat: on Saturday?

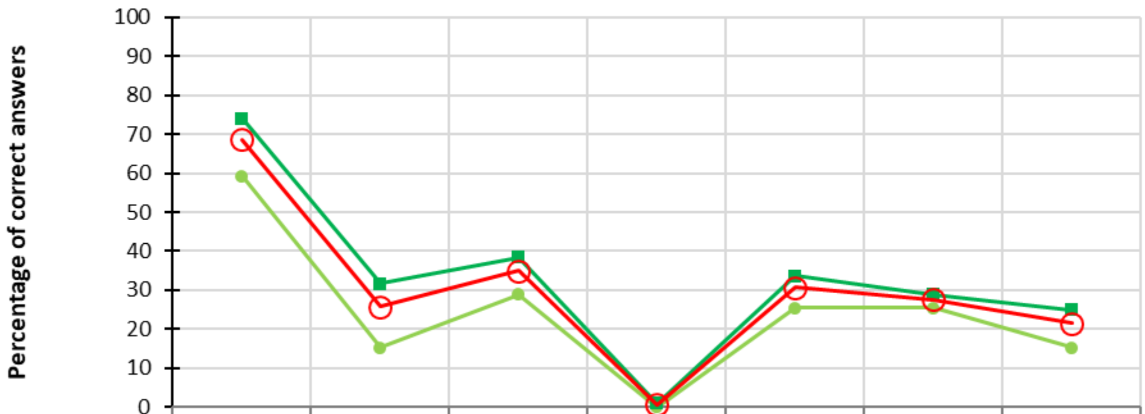
Q2f. On Sunday?

Q2g. On the weekend?

Figure 9 – Statement of Question 2 of the 2nd level (4th and 5th grade students).

Source: D-Estat data.

In Figure 10, we can see that most students were able to add by line; but in the sum per column the performance dropped to less than a third. The ordination did not exceed 40%; virtually no student was able to find the value of the central position, which indicates that the median for amount of data is not intuitive and needs instruction. Finding the three mean was around 25%, which we consider an unsatisfactory result, since the order of magnitude of the numbers was small, as well as the amount of data.



	SumL	SumC	Order	Median	Mean1	Mean2	Mean3
5th. grade	59,3	15,3	28,8	0,0	25,4	25,4	15,3
4th. grade	74,0	31,7	38,5	1,0	33,7	28,8	25,0
General	68,7	25,8	35,0	0,6	30,7	27,6	21,5

Figure 10 – Percentage of correct answers for 2nd level students in Question 2, per school grade.

Source: D-Estat data.

Question 3 was similar to that of the 1st level, with slightly higher numbers. In the case of Mode, we found that only 42.4% in the 4th grade and 76.9% in the 5th grade were able to identify it. As for the sum, we verified that only 18.6% of the 4th grade and 26% of the 5th grade were able to correctly add the six numbers, which indicates a lower performance to that of the 1st level.

Finalizing the analysis of the performance of the 2nd level students we present Figure 11. We observed that the number of blank answers increased considerably in relation to the 1st level and the item that stood out was the one that requested the quantity of chocolate snacks consumed on Saturday, Sunday and over the weekend (Q2b-SumC), which required

DOI: 10.20396/zet.v28i0.8656917

the sum of small values. We believe that, in this case, the tabular representation was an obstacle, because it presented several data points, in several columns, which is not commonly used in school.

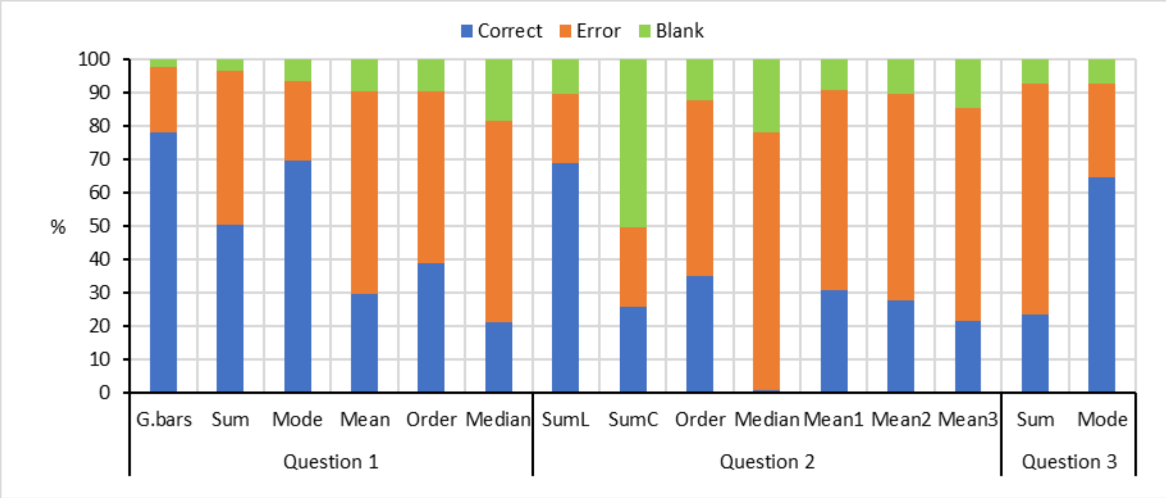


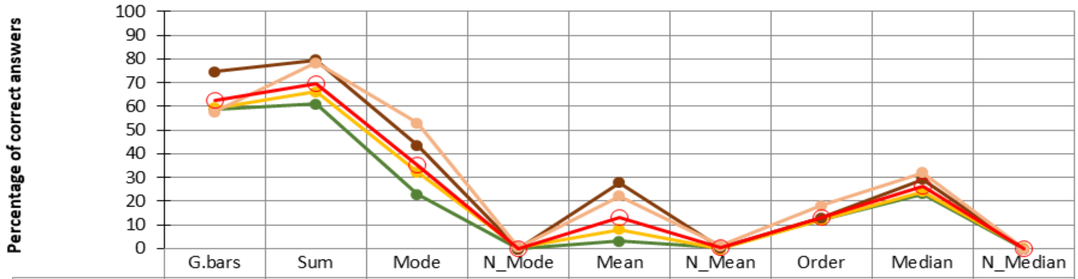
Figure 11 - Percentage distribution of correct, error and blank answers, by item, of 2nd level students. Source: D-Estat data.

Performance of students in the Middle School (3rd level)

Question 1 had a structure similar to that of the 2nd level instrument, changing only the name of the variable: "What Danilo's grandfather spent at the bakery during the past week, as shown in the following list (followed by the days of the week and the expense values from Monday to Sunday: 4, 4, 4, 5, 6, 10, 9)". Nine tasks were requested: convert the list data to a bar graph (G.Bars); find the total spent (Sum); identify the value that is repeated most often (Mode); explain the name of the Mode (N_Mode); divide the total spent by seven days: "Next week, Danilo's grandfather will spend the same amount, but in equal amounts every day. How much will he spend each day? (Mean); explain the name of the mean (N_Mean), order the values (Order); find the value that occupies the central position (Median) and explain the name of the Median (N_Median).

In Figure 12, we see that the students did better in converting the data to the graphical representation and performing the sum. In determining Mode, we see a very large variation reaching only 53%, the same for mean, which does not even reach 27.9%. The median performance did not exceed 32.2%. The results indicate performance stagnation in relation to schooling.

DOI: 10.20396/zet.v28i0.8656917



	G.bars	Sum	Mode	N_Mode	Mean	N_Mean	Order	Median	N_Median
6th. grade	58,9	61,1	22,9	0,0	3,2	0,3	12,1	23,2	0,0
7th. grade	59,3	66,1	32,3	0,4	8,1	0,0	12,1	24,2	0,4
8th. grade	74,8	79,7	43,7	0,0	27,9	0,5	13,1	29,3	0,0
9th. grade	57,7	78,5	53,0	0,7	22,1	1,3	18,1	32,2	0,0
General	62,6	69,7	35,2	0,2	13,4	0,4	13,3	26,4	0,1

Figure 12 – Percentage of correct answers for Middle Scholl students in Question 1, per school grade.

Source: D-Estat data.

As for the names of measure of center, virtually no students knew the answer. We observed that the majority of students made a mistake in ordering, since the data were ordered up to the penultimate element, which may have been misleading. However, this fact did not interfere in determining the Median, since the central position remained unchanged and, for this reason, the performance was slightly better than in the ordering.

Question 2 (Figure 13) was similar to that of the 2nd level, with the difference that in addition to the sum of the lines, the calculation of the mean, the lines and the columns were explicitly requested. The nine tasks were: sum and mean per lines (MeanL); sum by columns (SumC); mean in the 1st test (Mean1); mean in the 2nd test (Mean2); the mean in the two tests (Mean3); compare student means with the established limit and make a decision (Comparison1)"; mean property (Mean Prop); quantify the impact on the mean (How much), and finally, again comparison and decision making (Comparison2).

Q2. The math scores of a group of five students are the following.

Figure 1 - Score of five students in both tests

Student	1st test	2nd test	Total in both tests	Average of both tests
Bia	7	3		
Luiz	7	3		
Cléo	8	4		
Nina	6	2		
João	7	3		
Total group scores				

Q2a. Fill in the Figure the total points in the two tests and the average score of each student.

Q2b. Fill in the Figure the total points of the group in the 1st test and in the 2nd test.

Q2c. What was the group mean in the 1st test?

Q2d. What was the group mean in the 2nd test?

Q2e. What was the group mean in the two tests?

Q2f. If the minimum score to pass the discipline is 6, how many students would be approved?

Q2g. The Teacher verified that a second test question was wrong and decided to add two points to the score of all students. What happens to the average of the second test? How much?

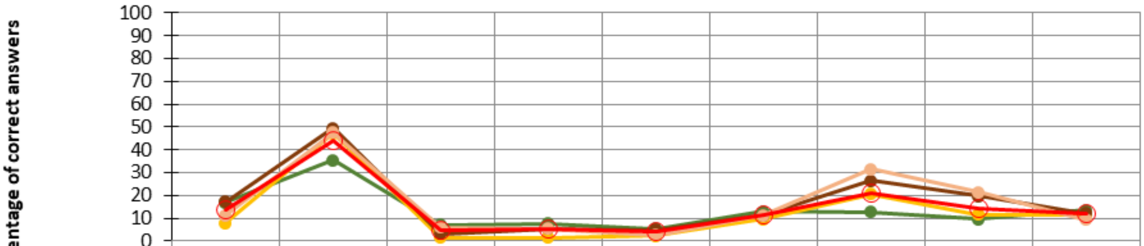
Q2h. In this case, how many students would be approved?

Figure 13 – Statement of Question 2 of the Middle School (3rd level).

DOI: 10.20396/zet.v28i0.8656917

Source: D-Estat data.

In Figure 14, we see that students performed worse in calculating the means per line (adding and dividing by two) and tests (dividing by 5). Less than half managed to add the columns. The failure in the overall mean made it difficult to make comparisons. We also observed that few students realized that increasing the score in the 2nd test by two points would increase the mean in the 2nd test by two points, and that this would impact one point in the overall mean, since there were two score. Few students were successful in this task.



	MeanL	S_column	Mean 2st. test	Mean 1st. test	Overall mean	Compa-rison1	Prop Mean	How much?	Compa-rison2
6th. grade	16,9	35,4	7,0	7,6	5,4	13,1	12,7	9,6	13,7
7th. grade	8,1	47,2	1,6	1,6	2,4	9,7	20,6	11,7	11,7
8th. grade	17,1	49,5	3,2	5,4	5,0	11,3	26,6	19,8	12,2
9th. grade	11,4	47,7	6,0	5,4	2,7	11,4	31,5	21,5	9,4
General	13,7	43,8	4,5	5,1	4,1	11,5	21,1	14,5	12,1

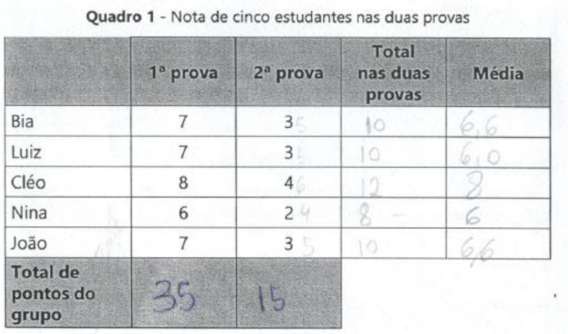
Figure 14 - Percentage of correct answers for Middle School students in Question 2, per school grade.

Source: D-Estat data.

When we elaborated the question, we believed that students would be very familiar with calculating the mean of the scores in tabular representation. In Figure 15 we present the extracts from the resolution of two students, in which we observe that the students perform the additions by lines (scores of each student) and columns (scores in each test) correctly, but the one on the left apparently added the three columns and divided it by three, which could be an indication of the mean concept, but which still needs instruction. The student on the right joined the two numbers, considering the score in the first test as the integer and the score in the second test as part of the decimal, signaling that he has no idea of the mean concept.

Figure 1 – Score of 5 students in both tests

1st test, 2nd test, Total of both tests, Mean



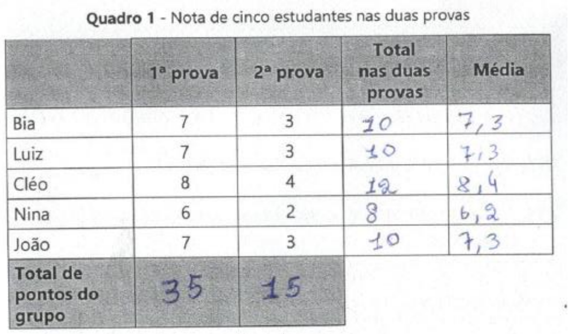
Quadro 1 - Nota de cinco estudantes nas duas provas

	1ª prova	2ª prova	Total nas duas provas	Média
Bia	7	3 5	10	6,6
Luiz	7	3	10	6,0
Cléo	8	4 6	12	8
Nina	6	2 4	8	6
João	7	3 5	10	6,6
Total de pontos do grupo	35	15		

Total scores of both groups

Figure 1 – Score of 5 students in both tests

1st test, 2nd test, Total of both tests, Mean



Quadro 1 - Nota de cinco estudantes nas duas provas

	1ª prova	2ª prova	Total nas duas provas	Média
Bia	7	3	10	7,3
Luiz	7	3	10	7,3
Cléo	8	4	12	8,4
Nina	6	2	8	6,2
João	7	3	10	7,3
Total de pontos do grupo	35	15		

Total scores of both groups

DOI: 10.20396/zet.v28i0.8656917

Figure 15 – Solution of two 9th grade students in determining the average per line.

Source: D-Estat data.

The drop in performance, when compared to Question 1, appears to indicate that students are not familiar with data in tabular registries. We observed that Luna and Carvalho (2019) found that the presentation of data in graphs hindered student performance. In the present study it seems that students are not used to working with data in tabular representation.

Question 3 was similar to that of the early years, but in a TDF double entry (Figure 16). It requested 10 more complex tasks, as it required an advanced level of data reading: the sum per line (Tot-line); the sum of the columns (Tot-C1, Tot-C2 and Tot-C3); the relative frequency of dogs for girls (% F); for boys (% M), establish a relationship between these relative frequencies (Relat1); indicate the relationship (Which1), the perception of the relationship between the variables (Relat2) and indicate the type of relationship (Which2).

Figure 2 – Number of students by gender, according to favorite pet

Favorite pet	Gender		Total
	Boys	Girls	
Cat	0	75	
Bird	15	15	
Dog	25	50	
Others (monkey, tortoise, etc.)	5	5	
None	5	5	
Total students			

Q3a. Fill in the Figure 2 with the total with which each animal was chosen.

Q3b. How many boys responded to the survey? How many girls? In all, how many students responded to the survey?

Q3c. Percentage of girls that chose Dog?

Q3d. Percentage of boys that chose Dog?

Q3e. Analyzing the data in the Figure 2 and the calculated percentages, can we say that girls prefer dogs more than boys? () No () Yes. Why?

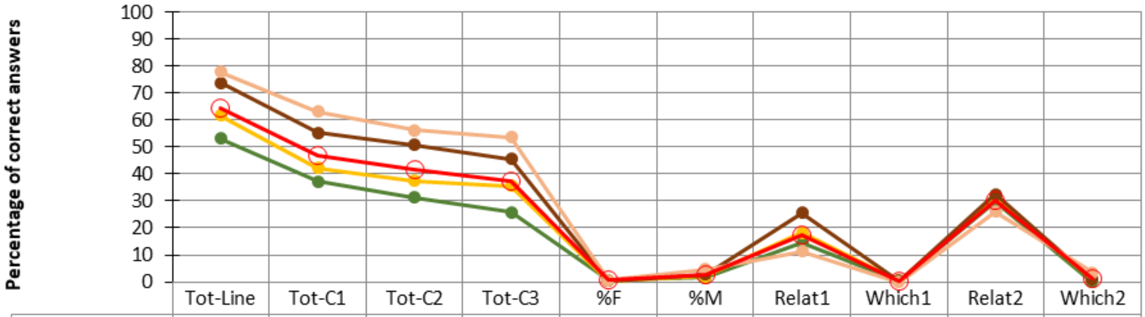
Q3f. Analyzing the data in the Figure 2, in your opinion, is there evidence of a relationship between the favorite pet and being a boy or girl? () No () Yes. Why?

Figure 16 – Statement of Question 3 of the Middle School.

Source: D-Estat data.

Figure 17 shows that the sum by lines was better performed than the sum by columns, and this execution was better performed according to the students' school grade. Very few students were able to calculate the relative frequency, the majority repeated the absolute frequency plus the symbol%, and the concept of percentage has been in the curriculum since the 5th grade. Few students were able to see the relationship between the variables, and when they made that relationship explicit, the justifications were given from their beliefs and not from the data.

DOI: 10.20396/zet.v28i0.8656917



	Tot-Line	Tot-C1	Tot-C2	Tot-C3	%F	%M	Relat1	Which1	Relat2	Which2
6th. grade	53,2	37,3	31,2	25,8	0,6	1,6	14,3	0,3	29,6	0,0
7th. grade	61,7	42,3	37,5	35,5	0,4	2,0	18,1	0,4	31,5	0,8
8th. grade	73,9	55,4	50,9	45,5	0,5	2,7	25,7	0,5	32,4	0,9
9th. grade	77,9	63,1	56,4	53,7	0,7	4,7	11,4	0,0	26,2	3,4
General	64,3	47,1	41,6	37,5	0,5	2,5	17,6	0,3	30,2	1,0

Figure 17 – Percentage of correct answers for Middle School students in Question 3, per school grade.

Source: D-Estat data.

Finishing the analysis of student performance in the final years, we present Figure 18.

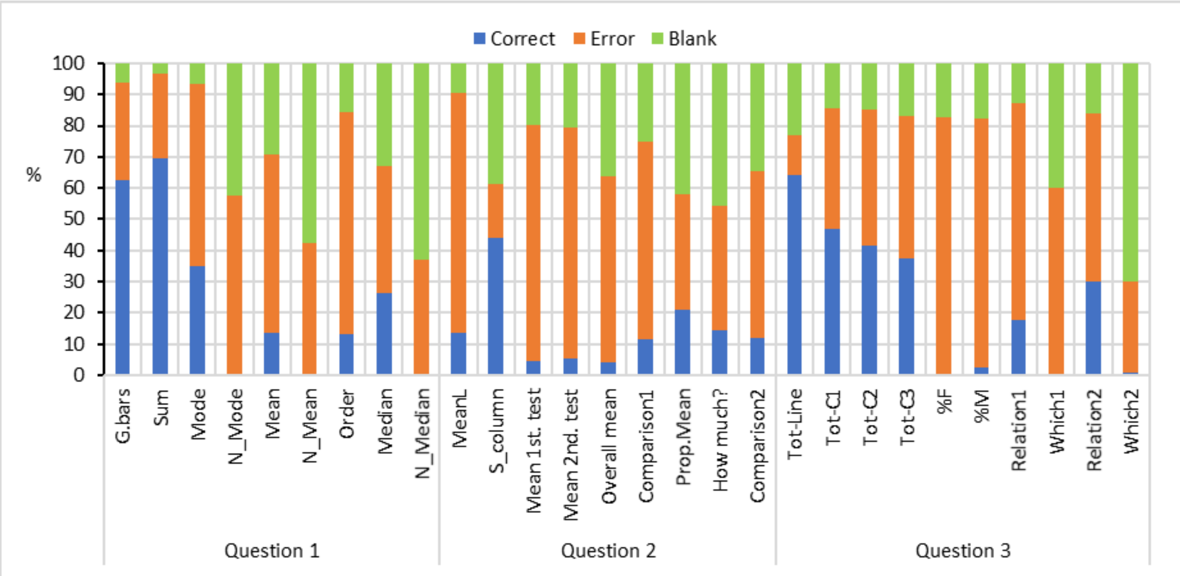


Figure 18 - Percentage distribution of correctness, error and blank, by item, of students of the Middle School.

Source: D-Estat data.

We observed that the percentage of correct answers drops significantly in relation to the two other levels, and the percentage of blank answers increases considerably. The items that presented the highest percentage of blank responses, greater than 50%, were those that requested the name of the statistical concept, mean, median and identifying the relationship between gender and favorite pet. We believe that these were also the items expected to cause the majority of incorrect answers, as school activities usually do not address the name of the concepts and do not require more than the elementary level of interpretation of a table or graph.

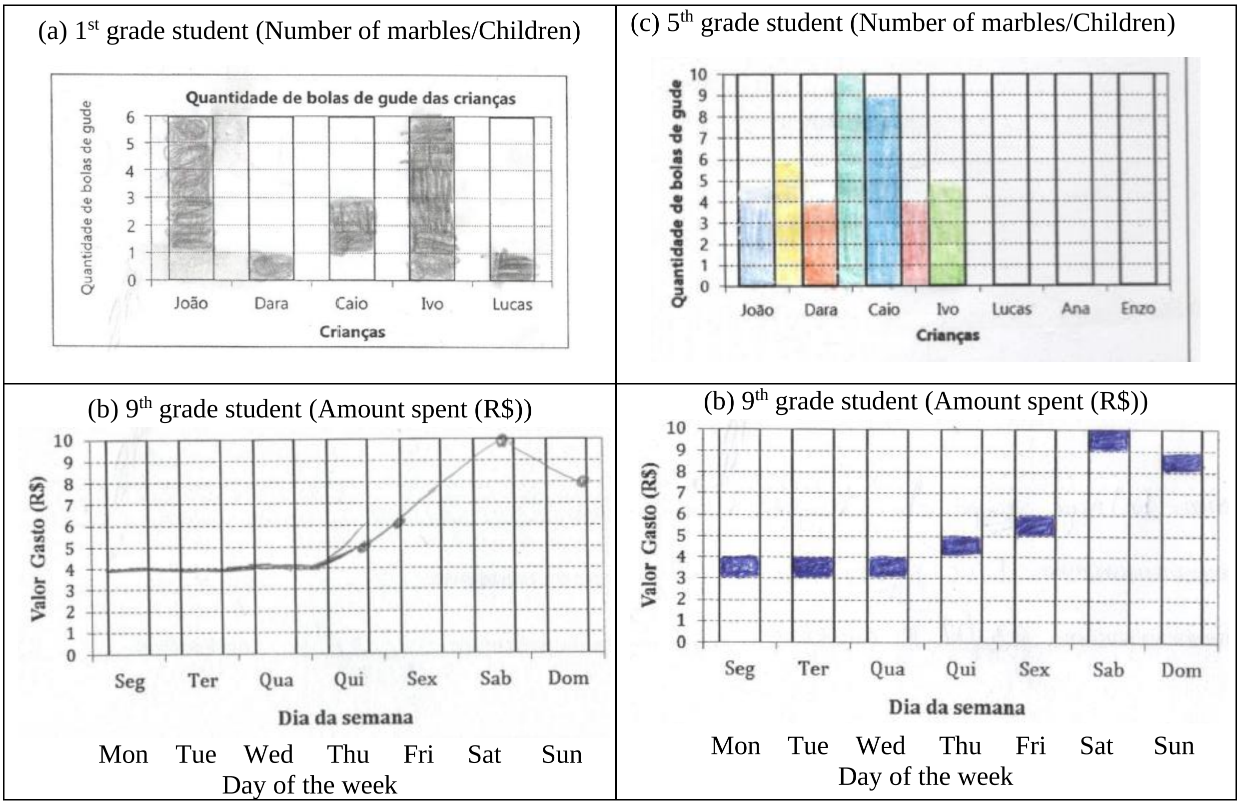
DOI: 10.20396/zet.v28i0.8656917

Global analysis of the performance of elementary school students

In this section, we draw parallels regarding performance in the three School levels. In Question 1 we can see that, in general, there is a performance increase over the school grade within each level, but there is a drop from one level to another, especially in the Middle School, particularly in the 9th grade.

In the conversion of native language data (1st level) and list (3rd level) to graphic representation (G.Bars), we see a clear performance increase in the Elementary School, going from less than 30%, in the 1st grade, to little more than 80% in the 5th grade; however, we observed stagnation in the final grade, at the level of 60%, with the exception of the 8th grade students, which reaches about 75%, but still below the performance achieved by the 5th grade students.

Among the main mistakes made in the conversion of native language data to the students' graphic registry, we exhibit them in Figure 19.



(a) 1st grade student (Number of marbles/Children)

(c) 5th grade student (Number of marbles/Children)

(b) 9th grade student (Amount spent (R$))

(b) 9th grade student (Amount spent (R$))

Figure 19 – Examples of errors when converting data to the bar graph.

Source: D-Estat data.

We found that in the Elementary School, some students who drew the correct quantity of rectangles, drew some bars without starting at the zero scale (19a), showing that they are still unable to relate the ordinate axis to the number of rectangles in each bar. Others drew the bars together (19b), in the order in which the data appeared, but were unable to relate the name of each child to the column; in the final years some students tried to make a line graph

DOI: 10.20396/zet.v28i0.8656917

(19c) and built a “band” graph (19d), and other depictions. These results lead us to agree with the conclusions of Carvalho, Oliveira and Monteiro (2019) regarding the need for teachers to emphasize the systematization of statistical information and the use of scale in bar graphs.

With regard to Mode, more than 60% of students in the 1st level were able to identify the amount that was repeated the most, in the Middle School this was not achieved in the 9th grade, which instead of answering that the amount spent most often was R$ 4.00, answered the maximum amount of expenses, R$ 10.00. Similarly, in the 5th grade, instead of answering that the number of marbles that were more repeated was 4, they answered the maximum amount, which was 10 marbles. These results are inconsistent with what is expected to occur: that the higher level of education leads to greater performance, as in the study by Luna and Carvalho (2019).

As for addition (Figure 20), we found that the performance of the 1st to the 3rd grade students went from 40% to 60%, with many students using pictorial representation as shown in Figure 20a; the performance of students in the 4th and 5th grades was around 50%, and those in the Middle School went from 60% in the 6th grade, to 80% in the 8th and 9th grades. Many students recorded several types of grouping, most of whom performed the correct calculation (20d). In Figure 20b and 20c we illustrate the calculation error.

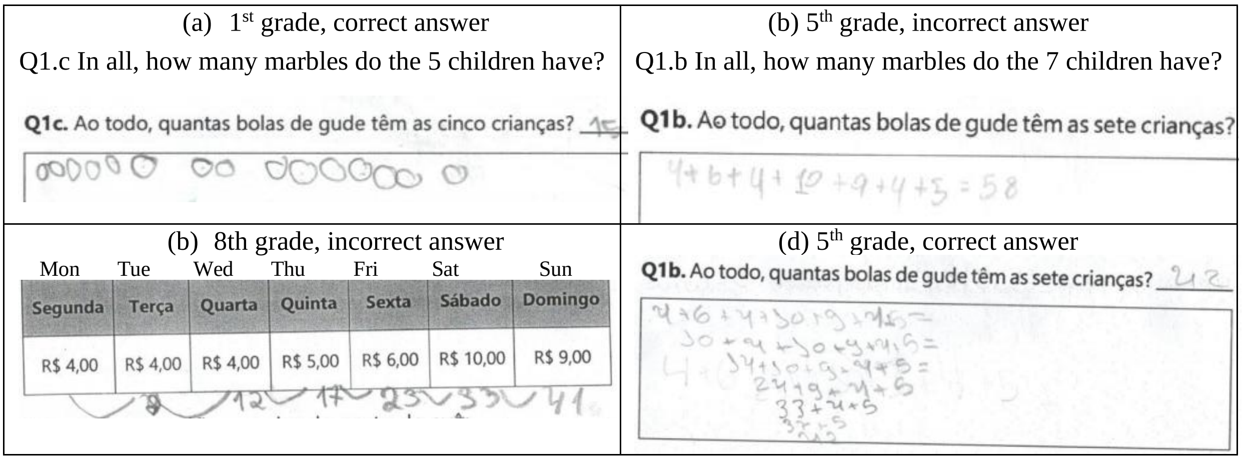


Figure 20 – Registry of the sum of some students.

Source: D-Estat data.

Regarding the mean, there is a substantial performance drop from one level to another, in which the numbers involved were small and the division exact, which allowed the use of alternative strategies for the division algorithm, as shown in Figure 21.

We observed that, in general, the rate of correct answers in the 1st level was 10% in the 1st grade to 45% in the 3rd grade; in the 4th grade it was around 25% and in the 5th grade 30%. In the Middle School, this index increased from 5% in the 6th grade to 30% in the 8th grade and dropped to 20% in the 9th grade.

Figure 21a shows that 3rd grade students used different types of pictorial representations; the 4th and 5th grade students used a mixture of the division algorithm and

DOI: 10.20396/zet.v28i0.8656917

representation with drawings (Figure 21b) and, in general, the students of the final grade only recorded the final result and most of them were wrong. In Figure 21c we illustrate the difficulty of an 8th grade student in the division algorithm, compromising the calculation of the mean, as in the results found by Luna and Carvalho (2019).

Regarding the performance in Question 2, whose data were presented in tabular register, we observed that, in the 1st level, after stagnation in the first two years, there is a significant increase in the 3rd grade; a substantial drop in the 4th and 5th grades and an even greater drop in the final grades.

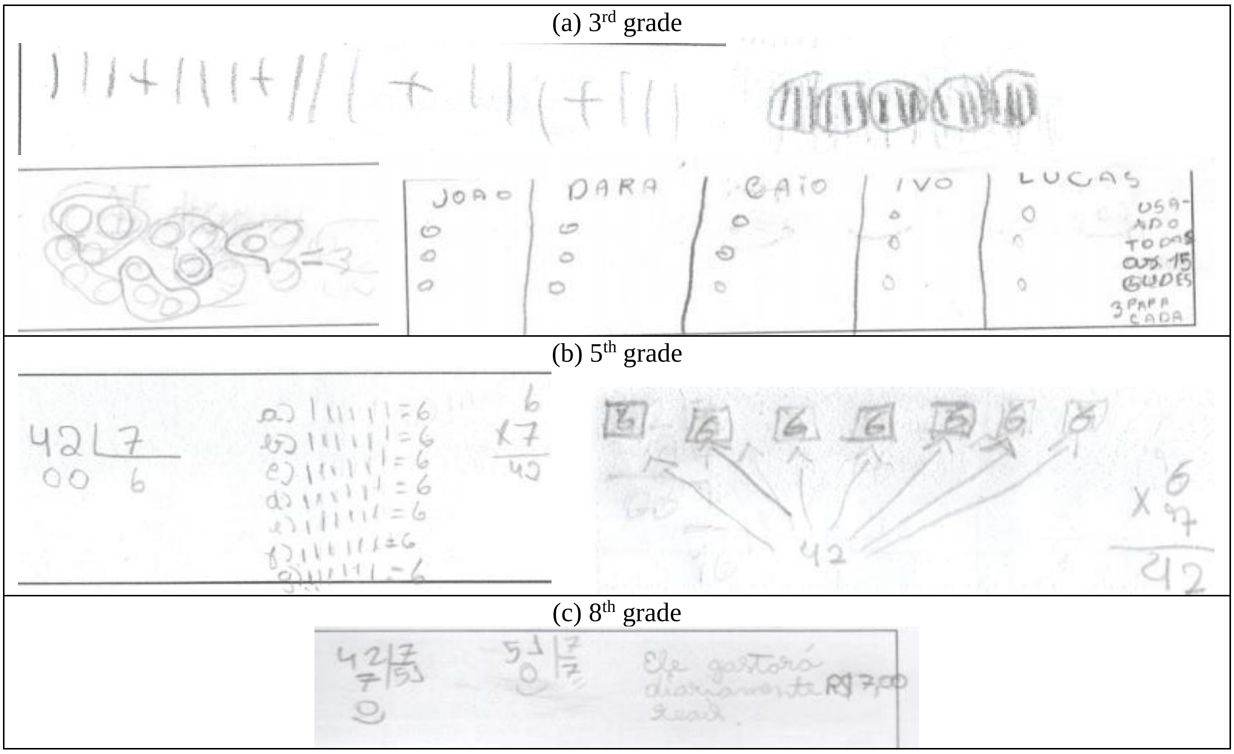


Figure 21 – Records of the mean of some students.

Source: D-Estat data.

Observing that in the 1st level it was a statistical table, with four numbers, the sum of which was 12, the 3rd grade students did relatively well in the sum and mean, often using the division in equal parts and pictorial representation, as shown Figure 22.

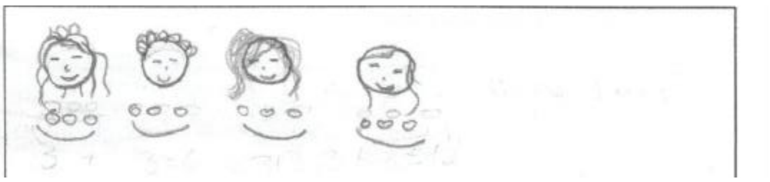


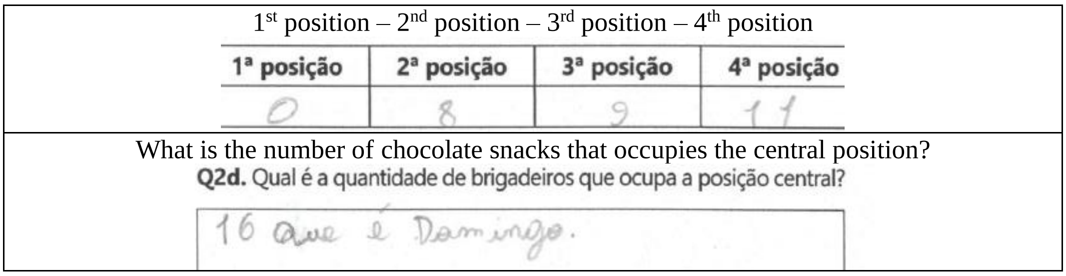
Figure 22– Register of the mean calculation of a 3rd grade student.

Source: D-Estat data.

With regard to the median, we can see that some students ordered the numbers correctly (Figure 23), but practically none could perceive that the median was between the

DOI: 10.20396/zet.v28i0.8656917

two values that occupied the central positions. This result is in agreement with the results of Mayén et al. (2007) who found that Mexican and Spanish students also found it difficult to determine the median due to the indeterminacy produced by having two central values. In addition, stating that the median is 16 shows that the student does not know that the median can only take values between the minimum and maximum values.



1st position – 2nd position – 3rd position – 4th position

1ª posição	2ª posição	3ª posição	4ª posição
0	8	9	11

What is the number of chocolate snacks that occupies the central position?

Q2d. Qual é a quantidade de brigadeiros que ocupa a posição central?

16 que é Domingo.

Figure 23 – Ordination and attempt to determine the median by a 5th grade student.

Source: D-Estat data.

Regarding Question 3, we found that in the Mode extraction (identifying the maximum in frequency distribution table), the 4th grade students have the worst performance and the 5th grade students tie with the 3rd grade students. This is worrying, as according to Curcio (1989) it is an elementary level reading. As for the sum, we observe that there are six numbers that change only the order of magnitude, therefore the drop in the 4th and 5th grade students is not justified. Similarly, the performance of the Middle School is worrying.

Final Considerations

The results of the present investigation are quite worrying, considering that the contents of Statistics in Elementary Education were inserted in 1997, but most students do not know how to identify the nomenclature when determining mean, median and mode. The results indicate that students are not familiar with the presentation of data in tabular or graphical register, corroborating the results of recent studies (Luna & Carvalho, 2019; Carvalho, Oliveira & Monteiro, 2019).

The level of tables and graphs-reading by students is nothing more than elementary, according to the classification of Curcio (1989) and Wainer (2002). The student that confused the mean with the most frequent value (Mode), with the maximum value or with the sum, has also been reported in other studies (Cobo & Batanero, 2004 and Mayén et al., 2007).

The results show that students have limitations with fundamental operations (addition and division) and reading comprehension, which are components of statistical literacy (Gal, 2002).

As study limitations, we inform that in recent years, our partner schools have been suffering from the lack and changes of mathematics teachers, strikes and interruptions. We also noticed that many students, especially from the Middle School, left questions unanswered (blank). However, this survey was also carried out in schools in Ceará, Natal and

DOI: 10.20396/zet.v28i0.8656917

São Paulo, which will allow verifying the local effect. In addition, we have been working with teachers at these schools for almost two years and a new survey is expected in 2020, when we expect more promising results.

Finally, we reiterate the need to develop teaching sequences that address topics of interest to students, as proposed by Santana (2006), which allow the use of different types of representation and registers such as those presented by Nascimento, Paula and Carneiro (2018) to contribute to the learning of statistical concepts, to mediate conflicts, to make personal or collective decisions as highlighted by Teixeira (2006), and to develop an inquisitive stance, making use of critical thinking as postulated by Gal (2002), Skovsmose (2008) and Santos and Branches (2019).

References

Campos, C. R., Wodewotzki, M. L. L. & Jacobini, O. R. (2013). Educação Estatística Teoria e prática em ambientes de modelagem matemática. Belo Horizonte: Autêntica.

Carvalho, L. M. T. L. de, Oliveira, S. A. P. de, & Monteiro, C. E. F. (2019). Possibilidades da Educação Estatística como forma de análise crítica da realidade na escola indígena. *Roteiro*, 44(2), 1-20.

Cazorla, I. M. & Oliveira, M. S. (2010). Para Saber mais. In I. Cazorla & E. Santana (Orgs.). *Do Tratamento da Informação ao Letramento Estatístico* (pp. 113-144). Itabuna: Via Litterarum.

Cazorla, I. M. & Santana, E. (2010). *Do Tratamento da Informação ao Letramento Estatístico*. Itabuna. Via Litterarum.

Cazorla, I. M., Santana. E. R. S. & Utsumi, M. C. (2019). O campo conceitual da média aritmética: uma primeira aproximação. *Revemat*, 14 (Edição Especial Educação Estatística), 1-21.

Curcio, F. R. (1989). *Developing graph comprehension*. Virginia: National Council of Teachers of Mathematics.

Gal, I. (2002). Adults' Statistical Literacy: Meanings, Components, Responsibilities. In: *International Statistical Review*, 1 – 25.

Luna, L. C. & Carvalho, J. I. F. (2019). “Oi, Quem está olhando minhas estatísticas?” – Uma discussão do desempenho de estudantes da Educação Básica sobre média aritmética. *Amazônia: Revista de Educação em Ciências e Matemáticas*, 15(33), 151-166.

Mayén, S., Cobo, B., Batanero, C. & Balderas, P. (2007). Comprensión de las medidas de posición central en estudiantes mexicanos de bachillerato. *Unión*, 9, 187-201

Ministério da Educação (MEC). (1997). *Parâmetros Curriculares Nacionais (PCN). Matemática.1 e 2 ciclos*. Brasília: MEC, Secretaria de Ensino Fundamental.

Ministério da Educação (MEC). (1998). *Parâmetros Curriculares Nacionais: Matemática*. Brasília: MEC, Secretaria de Educação Fundamental.

DOI: 10.20396/zet.v28i0.8656917

Ministério da Educação (MEC). (2018). *Base Nacional Comum* (BNCC). Disponível em: http://basenacionalcomum.mec.gov.br/wpcontent/uploads/2018/12/BNCC_19dez2018_site.pdf.

Nascimento, M. M., Paula, M. & Catarino, P. (2018). Sítio do pica-pau amarelo: uma atividade de Estatística no 2.º ciclo do ensino básico português. *Indagatio Didactica*, 10(4), 107-117.

Santana, E. & Cazorla, I. (2018). *Desenvolvimento profissional de professores que ensinam Matemática: D-Estat*. Projeto de pesquisa. Universidade Estadual de Santa Cruz, Ilhéus-BA.

Santana, M. de S. (2016). Traduzindo pensamento e letramento estatístico em atividades para sala de aula: construção de um produto educacional. *Bolema*, 30(56), 1165-1187.

Santos, R. M. dos & Branches, M. V. (2019). Problemas identificados em gráficos estatísticos publicados nos meios de comunicação. *Amazônia: Revista de Educação em Ciências e Matemáticas*, 15(33), 201-218.

Skovsmose, O. (2008). *Desafios da educação matemática crítica* [Challenges of Critical Mathematics Education]. São Paulo: Papirus.

Teixeira, P. J. M. (2016). Os PCN e o bloco Tratamento da Informação: algumas possibilidades teórico-metodológicas para a sala de aula da Educação Básica. *Remat*, 2(2), 72-91.

Wainer, H. (1992). Understanding graph and tables. *Educational Researcher*, 21(1), 14-23.